

Thesis
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Lundy
U. S. Naval Postgraduate School
Annapolis, Md.

GROUP EVALUATION OF THE ACCURACY OF A
SET OF TIME STANDARDS

A Thesis

Submitted to the Faculty

of

Purdue University

by

Joseph Hammond Earnest, Jr.

In Partial Fulfillment of the

Requirements for the Degree

of

Master of Science in Industrial Engineering

June, 1950

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AND JOHN H. HARRIS, JR.

ACKNOWLEDGMENT

The author is very grateful to all who have helped make this work possible, and wishes to express his sincere thanks to:

Dr. Marvin E. Mundel for his valuable guidance and help;

The Motion and Time Study Department Staff for their cooperation and generosity in the use of their equipment;

The Computing Laboratory for their valuable assistance in sorting the data;

My wife for assistance in processing the data;

The Work Session Personnel for their assistance and cooperation.

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ABSTRACT

In the field of time study perhaps the most difficult problem is the rating or relating of the performance to standard. Misunderstandings caused by inconsistent or inaccurate rating of performance can and do cause labor disturbances such as grievances or even strikes.

The problem of this thesis was to evaluate and compare the time study ratings of X Company¹ and the ratings of the other engineers in regard to any differences, if such exist, that might be caused by different concepts, different methods of rating, different geographical areas, different types of companies and types of work with which the time study men are familiar, differences in experience, differences in training, differences in the size of the town or differences in size of the company. Particular attention was given to the consistency of ratings used by X Company as evaluated by the experimental group.

To accomplish these objectives the films furnished by X Company were rated by time study engineers at the Fifth Annual Motion and Time Study Work Session by three methods:

1. A system similar to that used by Company X; viz., judgment of the raters for both a reasonable concept to compare to and a numerical appraisal in reference to this concept.
2. Single-image motion picture as standard or bench mark.
3. Multi-image motion picture with 12 different poses of the same job as a graduated bench mark.

1 X Company is the name assigned to conceal correct name of the concern actually involved.

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The data were classified by means of the questionnaire, and International Business Machine Equipment was used to sort and to tabulate the various subgroups.

After the ratings were brought to the same base and allowances were applied where required, comparisons of X Company and work session ratings were made by comparison graphs and least square lines to determine any differences, if such existed. To determine if such results could possibly have occurred by chance alone, or were statistically significant, "t" tests were made upon the above.

The following conclusions were made:

1. In the comparison of the best approximation of 100 by the work session using the judgment technique with X Company's concept of standard, the company averaged 17.3 per cent higher on the six jobs. Statistical "t" tests indicate that this difference is significant at the 5 per cent level. In other words, this difference could occur by chance only one time in twenty. In addition, Elia² found that 33 per cent of the work session engineers rated within ± 5 per cent, 43.4 within ± 7.5 , 58.3 within ± 10 and 84.6 per cent within ± 20 per cent of the overall means to which the X Company ratings were compared above.
2. In the comparison of the best approximation of 100 by the work session using the single-image bench mark with X Company's concept of standard, the company averaged 10.7 per cent higher on

2 Elia, A. J., An Analysis of Current Practice Time Study Ratings, Thesis Purdue University, 1950.

The first part of the report is devoted to a general survey of the situation in the country.

The second part contains a detailed account of the work done during the year.

The third part is devoted to a summary of the results of the work.

The fourth part contains a list of the names of the persons who have assisted in the work.

The fifth part is devoted to a summary of the results of the work.

The sixth part contains a list of the names of the persons who have assisted in the work.

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The eighteenth part contains a list of the names of the persons who have assisted in the work.

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The twentieth part contains a list of the names of the persons who have assisted in the work.

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The twenty-second part contains a list of the names of the persons who have assisted in the work.

The twenty-third part is devoted to a summary of the results of the work.

The twenty-fourth part contains a list of the names of the persons who have assisted in the work.

the six jobs. In the statistical "t" test, "t" was 0.61 which means that there was probably no statistically significant difference between the two concepts of standard. Sherwood³ found that 33 per cent of the work session engineers rated within ± 5 per cent, 48 per cent within $\pm 7\frac{1}{2}$ per cent, 58 within ± 10 and 89 within ± 20 of the overall means to which the X Company ratings were compared above.

3. There was no appreciable difference in the concepts of standards between the work session, using the Mundel⁴ method of rating and the multi-image bench mark, and the X Company. In the comparison of the best approximation of 100 by the work session and the company, the latter averaged 0.17 per cent lower on the six jobs. However, job number three was 27 per cent higher than the work session mean rating. Greenberger⁵ found that 36 per cent of the work session engineers rated within ± 5 per cent, 47 within $\pm 7\frac{1}{2}$, 62 within ± 10 , and 90 within ± 20 per cent of the overall means to which the X Company ratings were compared above.

3 Sherwood, W. G., An Evaluation of a Single Standard, Single Image Rating Aid for Time Study Rating, Thesis, Purdue University, 1950.

4 Mundel, M. E., Ph. D. Systematic Motion and Time Study, New York, Prentice-Hall Inc., 1947.

5 Greenburger, F. R., An Evaluation of the Mundel Multi-Image Rating Loop, Thesis, Purdue University, 1950.

the first part of the paper, the author discusses the
 various methods of determining the relative
 importance of the different factors in the
 model. It is shown that the relative importance
 of the factors can be determined by the
 method of partial correlation coefficients.
 The results of the analysis are presented in
 Table I.

It is shown that the relative importance of the
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INTRODUCTION

In the field of time study perhaps the most difficult problem is the rating or relating of the performance to the standard. Misunderstandings caused by inconsistent or inaccurate rating of performance can and do cause labor disturbances such as grievances or even strikes. Gomberg, head of the industrial management department of the International Ladies Garment Workers' Union, states that "all claims by engineers for their pet procedures rest upon an assumed validity of existing time study practices well within the percentage increment or decrement to the wage scale involved in collective bargaining negotiation. Obviously, if after months of negotiations and possible strikes at great financial sacrifice to both sides, a settlement has been reached involving a ten per cent change in the basic rates, neither management nor labor is prepared to sacrifice its respective rights to the blind operations of a technique of questionable accuracy.

"The use of a time study technique to set production standards whose demonstrated inaccuracy may exceed this percentage can become the source of much controversy."¹

There are many methods proposed for rating the performance of a worker. At the Fifth Annual Time Study Work Session, three methods were used. They were judgment, single-image standard film, and multi-image calibrated film. The first, judgment, consisted of the engineers using

1 Gomberg, W., A Trade Union Analysis of Time Study, Science Research Associates, Chicago, 1948, p. 14.

[illegible]

Handwritten text, likely bleed-through from the reverse side of the page, is visible at the bottom of the document. The text is mirrored and includes phrases such as "The one who is in the world" and "The one who is in the world".

These are the only subjects proposed for testing the performance of a system, in the fifth round. The other two subjects, given subjects were not, that were judged, specific-logic structure (SIS) and control-logic (SIS) were not. The first, judgment, consisted of the following using

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whatever method they normally used. The procedure, however, was, to a large extent, based upon the engineers' experience and ability to estimate the worker's performance and compare it to whatever concept of standard performance the engineers might have.

This method places two tasks upon the engineer. He must develop a mental concept of standard performance and then compare the employee's performance to this standard. Different concepts of standard performance between engineers of a particular company or between companies cause inconsistencies in ratings of the same performance under the same conditions. When the conditions change, the ratings should change. How much? The problem is to evaluate this difference. Here is another place for inaccuracy and inconsistency. From the above we see that the use of "judgment" technique for the time study rating might permit the occurrence of inconsistencies as a result of individual differences. Tiffin² states that in human endeavor individual differences exist as a normal distribution which approximates a bell-shaped curve, with most raters being near average and few being very high or very low.

In an attempt to find a solution for the above problem, Dr. M. E. Mundel³ proposed a technique of rating in which a physical representation of the standard is used; for example, a film of an industrial job. The single-image rating aid consists of a single loop of film of a laboratory job which was used as the standard for rating of the pace

2 Tiffin, J., Ph. D. Industrial Psychology, New York, Prentice-Hall Inc., 1947, p. 17.

3 Mundel, M. E., Ph. D. Systematic Motion and Time Study, New York, Prentice-Hall Inc., 1947, p. 159.

1. The first step is to identify the problem or question that needs to be answered. This involves understanding the context and the specific requirements of the task.

This subject should be dealt with in chapters. It may require a

[illegible]

...the world? The answer is in our hearts and in our minds. We are not alone in this world. We are part of a vast, interconnected web of life. We are part of a great, beautiful, and mysterious universe. We are part of a story that is still being written. We are part of a dream that is still being dreamed. We are part of a hope that is still being hoped for. We are part of a love that is still being loved. We are part of a life that is still being lived. We are part of a world that is still being discovered. We are part of a future that is still being imagined. We are part of a destiny that is still being written. We are part of a dream that is still being dreamed. We are part of a hope that is still being hoped for. We are part of a love that is still being loved. We are part of a life that is still being lived. We are part of a world that is still being discovered. We are part of a future that is still being imagined. We are part of a destiny that is still being written.

and other information. The information is being used for the purpose of the investigation and is being kept confidential.

It is also noted that the above information is not intended to be used for any purpose other than the one for which it was provided.

The above-mentioned results are consistent with the hypothesis that the

[illegible]

alone of the other jobs at the Work Session. Note, there is a fundamental difference. Under the "judgment" method the entire performance is evaluated against a judged concept, while under the Mundel system, only the pace is rated against an objective standard. Under the latter method, the three factors present are still acknowledged as determining the relative worth of the performance; they are skill, aptitude, and physical exertion. However, Mundel states that skill and aptitude both enter into pace, and physical exertion depends on pace and job difficulty. Only these last two factors are really appraisable. Job difficulty may be reduced to observable measurements which may be obtained from an allowance table leaving only pace to be evaluated.⁴ It is believed that the use of this film as a bench mark, or standard, will increase the accuracy and consistency of the ratings.

In addition, the multi-image film with twelve different paces of the same job was proposed as a graduated bench mark by Mundel for determining the rating of any job in order to eliminate, if possible, the tendency of time study engineers to rate all jobs alike: the slow, too high and the fast, too low.

As will be mentioned in detail in the procedure, X Company uses the "judgment" technique. In order to evaluate the ratings of the X Company, it was proposed to rate the films of their industrial jobs by the three techniques: "judgment", single-image and multi-image films.

⁴ Ibid, p. 163.

OBJECTIVE

The problem is to evaluate and compare the time study ratings of A Company and the ratings of the other engineers in regard to any differences, if such exist, that might be caused by basic inconsistencies, different methods of rating, different geographical areas, different types of companies and types of work with which the time study men are familiar, differences in experience, differences in training, differences in the size of the town, or differences in the size of the company.

PROCEDURE

Motion pictures of the industrial jobs were furnished by A Company. They consisted of films which X Company considered standard for each of the six jobs and other films from which short loops of each of the jobs at a faster and slower pace could be obtained.

The films were:		Name of Job
Job 1	Film 1. slower	evap. liq. inlet hand form 2nd & 3rd bend OPN #12
	2. standard	
	3. faster	
2	4. slower	assembly of thermo body, drive shaft, spring & screws OPN #18
	5. standard	
	6. faster	
3	7. slower	charging valve needle - hand burr hole and rethread OPN #5
	8. standard	
	9. faster	
4	10. slower	check diaphragm travel - thermo diaphragm OPN #11
	11. standard	
	12. faster	
5	13. slower	first bend (600 A cond. outlet conn.) OPN #11
	14. standard	
	15. faster	
6	16. slower	center folding 600 A liner - fold OPN #5
	17. standard	
	18. standard	

Careful analysis was made of the films for the proper allowances of each film and for the proper lengths of each cycle. The following total allowance⁵ was used for each job.

Job	Film	Allowance
1	1, 2, 3	14%
2	4, 5, 6	15%
3	7, 8, 9	12%
4	10, 11, 12	12%
5	13, 14, 15	10%
6	16, 17, 18	17%

⁵ These are the allowances required when the jobs were rated against a single-pace standard. See Mundel, W. E., op. cit., Chap. 13.

In determining the allowance, the following factors were considered: personal time, amount of body used, foot pedals, bimanualness, eye and hand coordination, handling requirements, weight handled, and percent of cycle controlled by machine.

The above 18 films were edited and calibrated by Tla and Radkins.⁶

To aid in the classification of the rating data, all the engineers at the work session filled out the questionnaire shown in the Appendix.

The questionnaire was discussed in detail by Borrus.⁷ In order to evaluate X Company ratings the following sub-groups were used:

1. Area
 - Northern Midwest
 - Central Midwest
 - Southern Midwest
 - Michigan
2. Experience
 - 0 - 6 Months
 - 6 Months - 2 Years
 - 2 - 4 Years
 - Over 4 Years
3. Rating Concept
 - Own Concept
 - Film or Other
4. Training
 - College
 - Company
5. Number of Employees
 - Under 200
 - 200 - 1000
 - Over 1000

⁶ Radkins, A. P., Comparison and Evaluation of Three Rating Techniques, Thesis, Purdue University, 1950.

⁷ Borrus, B. G., The Present State of Time Study, Thesis, Purdue University, 1950.

and the Commission, which will be in a position to make a final decision on the matter.

the same time, the Commission has been working to ensure that the information it receives is accurate and reliable. This has involved a number of steps, including the development of a code of ethics for its staff, the implementation of a system of internal controls, and the establishment of a process for the review and approval of all information received by the Commission.

1. The first step is to identify the problem or goal. This involves understanding the current situation and what needs to be achieved.

6. Size of Town

Under 5000
 5000 - 10,000
 10,000 - 25,000
 25,000 - 50,000
 50,000 - 100,000
 Over 100,000

A series of 12 films of the same job were calibrated by the engineers. These films were used as the basis for the single and multi-image standards in the latter phases of the work session.⁸ The corrected ratings of the engineers with one year, or more, experience were used to establish these bench marks.

The 18 films of X Company's six jobs of three pages each were then shown to the engineers in random order. They were asked to rate these films by whatever method they were accustomed to use. Their ratings were converted to the base of 150, the numerical designation given to the maximum average pace, and recorded upon IBM cards. The films were shown at 1000 cycles per minute and the speed was maintained constant by means of a stroboscope. No indications whatsoever, of the proper ratings, were given to the group.

Similarly, the 18 films of X Company were shown a second time. The engineers were requested to rate using the Mundel system⁹ with the single-image film, as a standard bench mark of 100 per cent. This aid was the one of the twelve films which they had previously rated as 100 on the base of 150 as the numerical designation given to the maximum

⁸ Lockett, L. S., An Evaluation of Time Study Ratings Made by a Group of Typical Time Study Engineers, Thesis, Purdue University, 1930.

⁹ Mundel, M. S., op. cit.

1. 1000 - 1000
2. 1000 - 1000
3. 1000 - 1000
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average pace. Later, they were asked to repeat the rating of 15 films using a multi-image film consisting of the 12 pieces that they had previously calibrated. Each was given a calibration chart (see Appendix) to aid in the rating. For details of the above three methods of rating, judgment, single aid, and multi-aid consult the theses of Ela,¹⁰ Sherwood¹¹ and Greenburger.¹² For a comparison of the three methods consult the thesis of Radkins.¹³

10 Ela, A. J., An Analysis of Current Practice Time Study Ratings, Thesis, Purdue University, 1930.

11 Sherwood, W. G., An Evaluation of a Single Standard, Single Image Rating Aid for Time Study Rating, Thesis, Purdue University, 1930.

12 Greenburger, E. M., An Evaluation of the Mundel Multi-Image Rating Loop, Thesis, Purdue University, 1930.

13 Radkins, A. P., op. cit.

over the past few years, it has been a great pleasure to have the opportunity to work with you and your staff. I am sure that the information you have provided will be of great value to the Commission. I am sure that the Commission will be able to make the best use of the information provided.

7-10-68
10-10-68

18	Continued, p. 2. The following is the text of the letter from the author to the publisher, dated 1950.
19	The following is the text of the letter from the publisher to the author, dated 1950.
20	The following is the text of the letter from the author to the publisher, dated 1950.

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DATA

The data were classified by means of the questionnaire. The following questions and subgroups were used to evaluate the ratings of the work session and to determine the differences, if any existed, between the ratings of the various subgroups and the ratings of X Company:

Question number 4) Area.

1. Northern Midwest except Michigan
2. Central Midwest
3. Southern Midwest
4. Michigan

6) Number of Employees in Plant.

1. Under 200
2. 200 to 1000
3. Over 1000

7) Length of Time You Have Been Taking Time Study.

1. Less than 6 Months actively engaged
2. 6 Months to 2 Years
3. 2 to 4 Years
4. Over 4 Years

8) Where Did You Receive Your Initial Time Study Training?

1. College
2. Company
3. Extension

11) With What Is Your Rating Compared?

1. Your concept of standard performance
2. Some film or other embodiment of standard performance

71) Size of Town in which Plant is Located.

1. Under 5000
2. 5000 - 10,000
3. 10,000 - 25,000
4. 25,000 - 50,000
5. 50,000 - 100,000
6. Over 100,000

International Business Machine equipment was used to sort and to tabulate the results for the above groupings.

The table is intended to show the following information and although the data is not complete, it is believed that the information is sufficient to show the following information and the results of the study.

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 - 3. The following information is provided:
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- 1. The following information is provided:
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- 1. The following information is provided:
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10. The following information is provided:
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 - 3. The following information is provided:
 - 4. The following information is provided:

Information is provided for the following information and the results of the study.

Corrected ratings were obtained from the average ratings by application of the formula $y' = \frac{y \sum xy}{\sum y^2}$. For derivation of this formula see Margolin.¹⁴ The corrected means were determined for all films using all three methods of rating for each of the above subgroups. For details see Ela,¹⁵ Sherwood¹⁶ and Greenburger's theses.¹⁷

In evaluating the ratings assigned by X Company to the three paces of the six industrial jobs, the ratings had to be converted to the same scale as used at the work session. In addition, allowances had to be added to the ratings where the single-image and the multi-image were used to make them comparable. The above was necessary because of differences between the Mundel and X Company definitions and concepts of the standard job and the maximum pace.

Company X states that the standard shall be such that "guaranteed piece work prices shall be set so that a normal employee or group of employees possessing normal skill and training, working under normal conditions, may by normal incentive effort, after making an honest effort to attain incentive earning over a reasonable trial period, have an opportunity to earn per pay period approximately 50% above his piece work base rate or their piece work base rates".¹⁸ Standard is defined by X Company as the time taken when the worker is earning this 50% increment. Dr. Mundel gives as his standard "the amount of time that will be necessary to

¹⁴ Margolin, L., A Comparison of Two Methods of Presentation for Time Study Rating, Thesis, Purdue University, 1950.

¹⁵ Ela, A. J., op. cit.

¹⁶ Sherwood, W. G., op. cit.

¹⁷ Greenburger, F., op. cit.

¹⁸ Contract between Y Union and X Company, 1949.

perform a unit of work, using a given method, under given conditions of work, by a worker possessing sufficient skill to perform the job properly, as physically fit for the job after adjustment to it as the average person who can be expected to be put on the job and working at a pace 100/150 per cent below the maximum pace that can be maintained day after day, without physical effects".¹⁹

These definitions indicate that there will be differences in the numerical value given to standard performance; i. e., a rating of 66.7 per cent with A Company is equal to 100 per cent Mundel except for the effect of Mundel's secondary adjustments. Company A rates the whole job compared to their concept of normal as indicated above. Mundel proposes a two-step rating procedure called objective rating. The steps are:

1. "The rating of observed pace against an objective pace-standard which is the same for all jobs. In this rating no attention whatsoever is paid to job difficulty and its effect on possible pace, hence, a single pace-standard may be used instead of a multiplicity of mental concepts.
2. "The use of a secondary adjustment, consisting of a percentage increment, added after the application of the numerical appraisal from step one has been used to adjust the original observed data. This percentage increment is to be taken from experimentally determined tables of the effect of various observable factors which control the exertion required at a given pace."²⁰ Hence, the true

¹⁹ Mundel, M. E., op. cit.

²⁰ Mundel, M. E., Motion and Time Study Principles and Practice, New York, Prentice-Hall, 1950.

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These findings indicate that there are no differences in the amount of value given to different categories of work, a finding of little consequence with respect to the way that work is valued, but the effect of gender is indirectly significant. Perhaps a factor like this has some effect on the way of doing an individual's work. Small differences in the way of doing an individual's work may have some effect on the way that work is valued. The effect was

1. The ending of the sentence "The ending of the sentence" is the same as the beginning of the sentence "The beginning of the sentence".

1. The use of a sampling instrument, consisting of a questionnaire, which allows the classification of the respondents according to their age and sex and to the type of business in which they are engaged. This questionnaire is to be sent to the respondents by mail.

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the polymer solution, and will be a function of the

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equivalent of 66.7 per cent rating of X Company in practice would be a case wherein the Mundle system rating multiplied by one plus the secondary adjustments given as decimals equaled 100 per cent.

From the above we see that the company's problem and work session item 3 was to rate the whole job including an appraisal of difficulty, while the work session, items 4 and 5²¹, simply rated the pace of the given job and required secondary adjustments for differences in job difficulty from the standard job to make the data comparable. After making the following corrections to the data: (1) conversion of X Company ratings to the base 130 maximum average pace and (2) application of allowances to single-image and multi-image ratings, the ratings of the company were compared to the three work session ratings by means of comparison graphs and least squares lines²² to determine any differences, if such existed, due to area, concept of standard, type of company, method of rating, number of employees and size of town.

To determine if such results could reasonably be ascribed to chance or were statistically significant,²³ 't' tests were made upon the results of the above comparisons.

21 Mundle, M. E., (Editor), Report of Fifth Annual Motion and Time Study Work Session, Purdue University, 1950.

22 Tiffin, J., op. cit.

23 Peters, C. C. and Van Voorhis, W. R., Statistical Procedures and their Mathematical Bases, McGraw-Hill Book Co., Inc., New York, 1940, p. 165.

These authors did not consider a significant difference between the two groups. The authors also did not consider the possibility that the two groups might have different levels of risk for the same outcome.

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of the above conditions.

[illegible]

RESULTS

In the comparison of the best approximation of 100 by work session using the various techniques and X Company's concept of standard, the following results were obtained:

Per Cent X Company Differs From Work Session:

Job Number	Judgment Rating	Single-Image	Multi-Image
1	25%	-14%	-14%
2	20	10	1
3	16	37	27
4	16	10	- 1
5	8	0	- 5
6	21	21	- 9
<hr/>			
Average Differences	17.3%	10.7%	- 0.17%

Note: See p. 3 for job name to identify above job number.

The purpose of the test is to determine the effect of the treatment on the response of the subjects.

The results of the test are shown in the following table:

The results of the test are shown in the following table:

The results of the test are shown in the following table:

Top Panel	Bottom Panel	Left Panel	Right Panel
1	2	3	4
5	6	7	8
9	10	11	12
13	14	15	16
17	18	19	20
21	22	23	24
25	26	27	28
29	30	31	32
33	34	35	36
37	38	39	40
41	42	43	44
45	46	47	48
49	50	51	52
53	54	55	56
57	58	59	60
61	62	63	64
65	66	67	68
69	70	71	72
73	74	75	76
77	78	79	80
81	82	83	84
85	86	87	88
89	90	91	92
93	94	95	96
97	98	99	100

The results of the test are shown in the following table:

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CONCLUSIONS

Factors that might have affected the results of the work session ratings were:

1. Since the engineers rated all day and did not use the multi-image technique until late in the afternoon, fatigue probably affected their ratings.
2. The possible influence of the seating arrangement was not considered.
3. The training curve was not considered. In the use of the new techniques, Greenburger²⁴ mentioned that consistency and accuracy improved with practice when using multi-image aid.
4. The difference in the size of multi-image individual pictures and the job picture may have been a factor. However, Radkins²⁵ stated that there was no significant difference between the three techniques (judgment, single aid and multi-aid) in regard to accuracy and consistency of ratings.

The conclusions drawn from this experiment, within the preceding limitations are:

1. In the comparison of the best approximation of 100 by the work session using the judgment technique and X Company's concept of standard, the company averaged 17.3 per cent higher on the six jobs. Statistical "t" tests indicate that this difference is significant at the 5 per cent level. In other words, this differ-

²⁴ Greenburger, F. R., op. cit.

²⁵ Radkins, A. P., op. cit.

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ence could occur by chance only one time in twenty or less. In addition, Sla²⁶ found that 33 per cent of the work session engineers rated within ± 5 per cent, 45.4 within ± 7.5 , 58.5 within ± 10 and 84.6 per cent within ± 20 per cent of the overall means to which the X Company ratings were compared above.

2. In the comparison of the best approximation of 100 by the work session using the single-image bench mark and X Company's concept of standard, the company averaged 10.7 per cent higher on the six jobs. In the statistical "t" test, "t" was 0.61 which means that there was no statistically reliable difference between the two concepts of standard. Sherwood²⁷ found that 33 per cent of the work session engineers rated within ± 5 per cent, 48 per cent within $\pm 7\frac{1}{2}$ per cent, 58 within ± 10 and 89 within ± 20 of the overall means to which the X Company ratings were compared above.
3. There was no appreciable difference in the concepts of standards between the ratings of the work session, using the Mundel²⁸ method of rating with the multi-image bench mark, and the X Company. In the comparison of the best approximation of 100 by the work session and the company, the latter averaged 0.17 per cent lower on the six jobs. However, job number three was 27 per cent higher than work session mean rating. Greenberger²⁹ found that 36 per cent of the work session engineers rated within ± 5 per cent,

26 Sla, A. J., op. cit.

27 Sherwood, W. A., op. cit.

28 Mundel, W. E., op. cit.

29 Greenberger, F., op. cit.

1. The first part of the paper is devoted to a study of the properties of the function $f(x)$ defined by the equation $f(x) = \sum_{n=0}^{\infty} \frac{x^n}{n!}$. It is shown that $f(x)$ is a continuous function of x and that $f(x) = e^x$ for all x .

2. In the second part of the paper the function $f(x)$ is studied for $x > 0$. It is shown that $f(x)$ is a strictly increasing function of x and that $f(x) > 1$ for all $x > 0$. It is also shown that $f(x)$ is a concave function of x for $x > 0$.

3. In the third part of the paper the function $f(x)$ is studied for $x < 0$. It is shown that $f(x)$ is a strictly decreasing function of x and that $f(x) < 1$ for all $x < 0$. It is also shown that $f(x)$ is a convex function of x for $x < 0$.

4. In the fourth part of the paper the function $f(x)$ is studied for $x = 0$. It is shown that $f(0) = 1$ and that $f'(0) = 1$.

5. In the fifth part of the paper the function $f(x)$ is studied for $x \in \mathbb{R}$. It is shown that $f(x)$ is a continuous function of x and that $f(x) = e^x$ for all $x \in \mathbb{R}$.

47 within $\pm 7\frac{1}{2}$, 62 within ± 10 , and 90 within ± 20 per cent of the overall means to which the X Company ratings were compared above.

In regard to the other parameters under investigation (area, training, number of employees, experience, concept of standard, and size of town) only the following were found to be significantly different from their respective "overall" work session ratings to warrant using for comparison with X Company ratings:

1. In analyzing the judgment technique ratings, Wla³⁰ found only the Michigan group significantly different from the overall ratings. When compared to X Company, the Michigan group using judgment were not significantly different from X Company. The company ratings were 9 per cent higher on the average.
2. In the use of the single-image aid as a bench mark, Sherwood³¹ found Michigan area and the college and company training significantly different from the "overall" work session ratings. However, when compared with X Company ratings the Michigan single-image ratings were not significantly different. The company ratings were 1.7 per cent higher on the average. Also, both the college and the company trained men appeared not statistically significantly different at the one per cent level when compared to the X Company. The X Company differed from them by 16.85 and 15.25 per cent higher, respectively.

³⁰ Wla, A. J., op. cit.

³¹ Sherwood, W. G., op. cit.

3. Although Greenburger found that when the work session engineers used the multi-image bench mark, the Michigan area, and the college and company trained men were significantly different from the "overall" ratings, when compared to X Company there was no statistical significance. The company ratings were 1.7, 9 and 6.8 per cent higher respectively than the above subgroups.

Note: It was unfortunate that there was available only one X Company rating for each film and therefore no check on the internal consistency of the ratings of X Company engineers could be made by comparison with the work session ratings.

APPENDIX

TABLE 1

OVER ALL

Film No.	K Co. Rating Base 150	Own Concept Wk. Session Rating W.	1+allow. (Multi)	Corrected Single-Image Rating	Single-Image Rating Allow.	Corrected Multi-Image Rating	Multi-Image Rating & Allow.
1	127	104	1.14	98	112	100	114
2	130	105		100	114	102	116
3	151	122		115	131	118	134
4	104	87	1.15	83	94	91	103
5	130	109		105	119	114	129
6	172	144		138	156	150	170
7	116	90	1.12	75	84	81	91
8	130	101		85	95	91	102
9	150	116		97	109	105	118
10	121	104	1.12	97	109	110	123
11	130	112		105	118	118	132
12	167	143		134	150	152	170
13	117	100	1.10	106	117	110	121
14	130	120		117	129	121	133
15	123	114		111	122	115	126
16	138	107	1.19	96	114	109	120
17	143	115		104	124	113	124
18	143	115		104	124	113	124

Note: See p. 5 for names of films to identify above film numbers.

Station No.	Station Name	Station No.	Station Name	Station No.	Station Name	Station No.	Station Name
101	101	102	102	103	103	104	104
105	105	106	106	107	107	108	108
109	109	110	110	111	111	112	112
113	113	114	114	115	115	116	116
117	117	118	118	119	119	120	120
121	121	122	122	123	123	124	124
125	125	126	126	127	127	128	128
131	131	132	132	133	133	134	134
135	135	136	136	137	137	138	138
141	141	142	142	143	143	144	144
145	145	146	146	147	147	148	148
151	151	152	152	153	153	154	154
155	155	156	156	157	157	158	158
161	161	162	162	163	163	164	164
165	165	166	166	167	167	168	168
171	171	172	172	173	173	174	174
175	175	176	176	177	177	178	178
181	181	182	182	183	183	184	184
185	185	186	186	187	187	188	188
191	191	192	192	193	193	194	194
195	195	196	196	197	197	198	198
201	201	202	202	203	203	204	204

Station No. 101 is the same as Station No. 102 for the purpose of this comparison.

TABLE 2

Area Ratings Using Judgment

Film No.	Group 1	Group 2	Group 3	Group 4
1	101	101	107	114
2	103	102	109	116
3	119	118	126	134
4	84	85	92	95
5	106	106	115	119
6	139	140	152	157
7	88	90	90	93
8	99	101	100	105
9	113	116	115	120
10	105	102	106	111
11	111	110	114	120
12	142	140	146	155
13	111	105	110	111
14	123	116	122	123
15	116	110	116	117
16	108	103	111	115
17	116	111	119	121
18	116	111	119	121

Note: See p. 3 for the names of the films.

Table 1

Frequency of the letters in the alphabet

A	B	C	D	E
1	2	3	4	5
6	7	8	9	10
11	12	13	14	15
16	17	18	19	20
21	22	23	24	25
26	27	28	29	30
31	32	33	34	35
36	37	38	39	40
41	42	43	44	45
46	47	48	49	50
51	52	53	54	55
56	57	58	59	60
61	62	63	64	65
66	67	68	69	70
71	72	73	74	75
76	77	78	79	80
81	82	83	84	85
86	87	88	89	90
91	92	93	94	95
96	97	98	99	100

Source: The letters of the alphabet are arranged in order of frequency.

Table 1 shows the frequency of the letters in the alphabet. The letters are arranged in order of frequency, from most frequent to least frequent.

TABLE 3

Area Ratings Plus Allowances Using Single Aid

Film No.	Group 1	Group 2	Group 3	Group 4
1	113	115	112	115
2	109	114	113	116
3	128	132	131	135
4	90	96	99	102
5	114	121	124	130
6	150	159	164	171
7	81	87	91	88
8	91	97	91	100
9	104	112	104	114
10	102	107	112	116
11	110	116	121	125
12	141	153	156	160
13	111	114	114	118
14	123	127	128	130
15	117	121	121	125
16	119	120	118	126
17	124	125	125	131
18	124	125	125	131

TABLE 1

Summary of the results of the analysis of variance for the effect of the treatment on the response

Treatment	Control	Low	High	Mean
1	1.0	1.0	1.0	1.0
2	1.0	1.0	1.0	1.0
3	1.0	1.0	1.0	1.0
4	1.0	1.0	1.0	1.0
5	1.0	1.0	1.0	1.0
6	1.0	1.0	1.0	1.0
7	1.0	1.0	1.0	1.0
8	1.0	1.0	1.0	1.0
9	1.0	1.0	1.0	1.0
10	1.0	1.0	1.0	1.0
11	1.0	1.0	1.0	1.0
12	1.0	1.0	1.0	1.0
13	1.0	1.0	1.0	1.0
14	1.0	1.0	1.0	1.0
15	1.0	1.0	1.0	1.0
16	1.0	1.0	1.0	1.0
17	1.0	1.0	1.0	1.0
18	1.0	1.0	1.0	1.0
19	1.0	1.0	1.0	1.0
20	1.0	1.0	1.0	1.0
21	1.0	1.0	1.0	1.0
22	1.0	1.0	1.0	1.0
23	1.0	1.0	1.0	1.0
24	1.0	1.0	1.0	1.0
25	1.0	1.0	1.0	1.0
26	1.0	1.0	1.0	1.0
27	1.0	1.0	1.0	1.0
28	1.0	1.0	1.0	1.0
29	1.0	1.0	1.0	1.0
30	1.0	1.0	1.0	1.0
31	1.0	1.0	1.0	1.0
32	1.0	1.0	1.0	1.0
33	1.0	1.0	1.0	1.0
34	1.0	1.0	1.0	1.0
35	1.0	1.0	1.0	1.0
36	1.0	1.0	1.0	1.0
37	1.0	1.0	1.0	1.0
38	1.0	1.0	1.0	1.0
39	1.0	1.0	1.0	1.0
40	1.0	1.0	1.0	1.0
41	1.0	1.0	1.0	1.0
42	1.0	1.0	1.0	1.0
43	1.0	1.0	1.0	1.0
44	1.0	1.0	1.0	1.0
45	1.0	1.0	1.0	1.0
46	1.0	1.0	1.0	1.0
47	1.0	1.0	1.0	1.0
48	1.0	1.0	1.0	1.0
49	1.0	1.0	1.0	1.0
50	1.0	1.0	1.0	1.0
51	1.0	1.0	1.0	1.0
52	1.0	1.0	1.0	1.0
53	1.0	1.0	1.0	1.0
54	1.0	1.0	1.0	1.0
55	1.0	1.0	1.0	1.0
56	1.0	1.0	1.0	1.0
57	1.0	1.0	1.0	1.0
58	1.0	1.0	1.0	1.0
59	1.0	1.0	1.0	1.0
60	1.0	1.0	1.0	1.0
61	1.0	1.0	1.0	1.0
62	1.0	1.0	1.0	1.0
63	1.0	1.0	1.0	1.0
64	1.0	1.0	1.0	1.0
65	1.0	1.0	1.0	1.0
66	1.0	1.0	1.0	1.0
67	1.0	1.0	1.0	1.0
68	1.0	1.0	1.0	1.0
69	1.0	1.0	1.0	1.0
70	1.0	1.0	1.0	1.0
71	1.0	1.0	1.0	1.0
72	1.0	1.0	1.0	1.0
73	1.0	1.0	1.0	1.0
74	1.0	1.0	1.0	1.0
75	1.0	1.0	1.0	1.0
76	1.0	1.0	1.0	1.0
77	1.0	1.0	1.0	1.0
78	1.0	1.0	1.0	1.0
79	1.0	1.0	1.0	1.0
80	1.0	1.0	1.0	1.0
81	1.0	1.0	1.0	1.0
82	1.0	1.0	1.0	1.0
83	1.0	1.0	1.0	1.0
84	1.0	1.0	1.0	1.0
85	1.0	1.0	1.0	1.0
86	1.0	1.0	1.0	1.0
87	1.0	1.0	1.0	1.0
88	1.0	1.0	1.0	1.0
89	1.0	1.0	1.0	1.0
90	1.0	1.0	1.0	1.0
91	1.0	1.0	1.0	1.0
92	1.0	1.0	1.0	1.0
93	1.0	1.0	1.0	1.0
94	1.0	1.0	1.0	1.0
95	1.0	1.0	1.0	1.0
96	1.0	1.0	1.0	1.0
97	1.0	1.0	1.0	1.0
98	1.0	1.0	1.0	1.0
99	1.0	1.0	1.0	1.0
100	1.0	1.0	1.0	1.0

TABLE 4

Area Ratings Plus Allowances Using Multi-Aid

Film No.	Group 1	Group 2	Group 3	Group 4
1	114	116	108	117
2	113	117	111	118
3	133	137	128	138
4	98	104	102	107
5	124	131	128	136
6	164	172	168	179
7	83	94	84	101
8	93	103	94	112
9	110	121	109	129
10	119	123	121	129
11	128	134	130	139
12	164	172	167	177
13	121	124	113	128
14	134	138	123	141
15	128	130	120	134
16	130	127	131	134
17	134	132	136	139
18	134	132	136	139

Table 1

Summary of the data for the first 100 observations

Year	Q1	Q2	Q3	Q4	Mean
1970	1.2	1.5	1.8	2.1	1.65
1971	1.3	1.6	1.9	2.2	1.75
1972	1.4	1.7	2.0	2.3	1.85
1973	1.5	1.8	2.1	2.4	1.95
1974	1.6	1.9	2.2	2.5	2.05
1975	1.7	2.0	2.3	2.6	2.15
1976	1.8	2.1	2.4	2.7	2.25
1977	1.9	2.2	2.5	2.8	2.35
1978	2.0	2.3	2.6	2.9	2.45
1979	2.1	2.4	2.7	3.0	2.55
1980	2.2	2.5	2.8	3.1	2.65
1981	2.3	2.6	2.9	3.2	2.75
1982	2.4	2.7	3.0	3.3	2.85
1983	2.5	2.8	3.1	3.4	2.95
1984	2.6	2.9	3.2	3.5	3.05
1985	2.7	3.0	3.3	3.6	3.15
1986	2.8	3.1	3.4	3.7	3.25
1987	2.9	3.2	3.5	3.8	3.35
1988	3.0	3.3	3.6	3.9	3.45
1989	3.1	3.4	3.7	4.0	3.55
1990	3.2	3.5	3.8	4.1	3.65
1991	3.3	3.6	3.9	4.2	3.75
1992	3.4	3.7	4.0	4.3	3.85
1993	3.5	3.8	4.1	4.4	3.95
1994	3.6	3.9	4.2	4.5	4.05
1995	3.7	4.0	4.3	4.6	4.15
1996	3.8	4.1	4.4	4.7	4.25
1997	3.9	4.2	4.5	4.8	4.35
1998	4.0	4.3	4.6	4.9	4.45
1999	4.1	4.4	4.7	5.0	4.55
2000	4.2	4.5	4.8	5.1	4.65
2001	4.3	4.6	4.9	5.2	4.75
2002	4.4	4.7	5.0	5.3	4.85
2003	4.5	4.8	5.1	5.4	4.95
2004	4.6	4.9	5.2	5.5	5.05
2005	4.7	5.0	5.3	5.6	5.15
2006	4.8	5.1	5.4	5.7	5.25
2007	4.9	5.2	5.5	5.8	5.35
2008	5.0	5.3	5.6	5.9	5.45
2009	5.1	5.4	5.7	6.0	5.55
2010	5.2	5.5	5.8	6.1	5.65
2011	5.3	5.6	5.9	6.2	5.75
2012	5.4	5.7	6.0	6.3	5.85
2013	5.5	5.8	6.1	6.4	5.95
2014	5.6	5.9	6.2	6.5	6.05
2015	5.7	6.0	6.3	6.6	6.15
2016	5.8	6.1	6.4	6.7	6.25
2017	5.9	6.2	6.5	6.8	6.35
2018	6.0	6.3	6.6	6.9	6.45
2019	6.1	6.4	6.7	7.0	6.55
2020	6.2	6.5	6.8	7.1	6.65
2021	6.3	6.6	6.9	7.2	6.75
2022	6.4	6.7	7.0	7.3	6.85
2023	6.5	6.8	7.1	7.4	6.95
2024	6.6	6.9	7.2	7.5	7.05
2025	6.7	7.0	7.3	7.6	7.15
2026	6.8	7.1	7.4	7.7	7.25
2027	6.9	7.2	7.5	7.8	7.35
2028	7.0	7.3	7.6	7.9	7.45
2029	7.1	7.4	7.7	8.0	7.55
2030	7.2	7.5	7.8	8.1	7.65

TABLE 5

Training Ratings Using Judgment

Film No.	Group 1	Group 2
1	104	105
2	106	107
3	122	123
4	89	87
5	113	109
6	149	143
7	89	91
8	106	102
9	114	118
10	104	105
11	112	113
12	144	144
13	109	109
14	120	121
15	114	115
16	107	108
17	113	116
18	113	116

Table 2

Summary of the data for the first 100 cases

Case No.	Age (yr)	Sex	Height (cm)	Weight (kg)
1	20	M	170	65
2	21	F	165	55
3	22	M	175	70
4	23	F	160	50
5	24	M	172	68
6	25	F	168	58
7	26	M	178	72
8	27	F	162	52
9	28	M	174	69
10	29	F	166	56
11	30	M	176	71
12	31	F	164	54
13	32	M	173	67
14	33	F	167	57
15	34	M	177	73
16	35	F	161	51
17	36	M	171	66
18	37	F	169	59
19	38	M	179	74
20	39	F	163	53
21	40	M	175	70
22	41	F	165	56
23	42	M	174	68
24	43	F	166	57
25	44	M	176	71
26	45	F	164	54
27	46	M	173	67
28	47	F	167	57
29	48	M	177	73
30	49	F	161	51
31	50	M	171	66
32	51	F	169	59
33	52	M	179	74
34	53	F	163	53
35	54	M	175	70
36	55	F	165	56
37	56	M	174	68
38	57	F	166	57
39	58	M	176	71
40	59	F	164	54
41	60	M	173	67
42	61	F	167	57
43	62	M	177	73
44	63	F	161	51
45	64	M	171	66
46	65	F	169	59
47	66	M	179	74
48	67	F	163	53
49	68	M	175	70
50	69	F	165	56
51	70	M	174	68
52	71	F	166	57
53	72	M	176	71
54	73	F	164	54
55	74	M	173	67
56	75	F	167	57
57	76	M	177	73
58	77	F	161	51
59	78	M	171	66
60	79	F	169	59
61	80	M	179	74
62	81	F	163	53
63	82	M	175	70
64	83	F	165	56
65	84	M	174	68
66	85	F	166	57
67	86	M	176	71
68	87	F	164	54
69	88	M	173	67
70	89	F	167	57
71	90	M	177	73
72	91	F	161	51
73	92	M	171	66
74	93	F	169	59
75	94	M	179	74
76	95	F	163	53
77	96	M	175	70
78	97	F	165	56
79	98	M	174	68
80	99	F	166	57
81	100	M	176	71

TABLE 6

Training Ratings Plus Allowances Using Single-Image Film

Film No.	Group 1	Group 2
1	109	115
2	112	114
3	129	132
4	96	95
5	121	120
6	159	158
7	82	85
8	92	96
9	105	111
10	109	109
11	118	116
12	150	149
13	112	116
14	125	128
15	118	121
16	119	120
17	123	125
18	125	125

Table 1

Summary of the results of the analysis of variance for the different factors

Factor	Level	Mean	Standard Error	Sum of Squares
1	1	100	10	100
2	1	100	10	100
3	1	100	10	100
4	1	100	10	100
5	1	100	10	100
6	1	100	10	100
7	1	100	10	100
8	1	100	10	100
9	1	100	10	100
10	1	100	10	100
11	1	100	10	100
12	1	100	10	100
13	1	100	10	100
14	1	100	10	100
15	1	100	10	100
16	1	100	10	100
17	1	100	10	100
18	1	100	10	100
19	1	100	10	100
20	1	100	10	100
21	1	100	10	100
22	1	100	10	100
23	1	100	10	100
24	1	100	10	100
25	1	100	10	100
26	1	100	10	100
27	1	100	10	100
28	1	100	10	100
29	1	100	10	100
30	1	100	10	100
31	1	100	10	100
32	1	100	10	100
33	1	100	10	100
34	1	100	10	100
35	1	100	10	100
36	1	100	10	100
37	1	100	10	100
38	1	100	10	100
39	1	100	10	100
40	1	100	10	100
41	1	100	10	100
42	1	100	10	100
43	1	100	10	100
44	1	100	10	100
45	1	100	10	100
46	1	100	10	100
47	1	100	10	100
48	1	100	10	100
49	1	100	10	100
50	1	100	10	100
51	1	100	10	100
52	1	100	10	100
53	1	100	10	100
54	1	100	10	100
55	1	100	10	100
56	1	100	10	100
57	1	100	10	100
58	1	100	10	100
59	1	100	10	100
60	1	100	10	100
61	1	100	10	100
62	1	100	10	100
63	1	100	10	100
64	1	100	10	100
65	1	100	10	100
66	1	100	10	100
67	1	100	10	100
68	1	100	10	100
69	1	100	10	100
70	1	100	10	100
71	1	100	10	100
72	1	100	10	100
73	1	100	10	100
74	1	100	10	100
75	1	100	10	100
76	1	100	10	100
77	1	100	10	100
78	1	100	10	100
79	1	100	10	100
80	1	100	10	100
81	1	100	10	100
82	1	100	10	100
83	1	100	10	100
84	1	100	10	100
85	1	100	10	100
86	1	100	10	100
87	1	100	10	100
88	1	100	10	100
89	1	100	10	100
90	1	100	10	100
91	1	100	10	100
92	1	100	10	100
93	1	100	10	100
94	1	100	10	100
95	1	100	10	100
96	1	100	10	100
97	1	100	10	100
98	1	100	10	100
99	1	100	10	100
100	1	100	10	100

TABLE 7

Training Ratings Plus Allowances Using Multi-Image Film

Film No.	Group 1	Group 2
1	113	115
2	115	116
3	132	136
4	104	102
5	130	128
6	171	168
7	84	94
8	94	104
9	109	121
10	121	124
11	131	134
12	167	172
13	121	120
14	135	132
15	127	125
16	129	150
17	133	154
18	133	154

TABLE 8

Number of Employees Ratings Using Judgment

Film No.	Group 1	Group 2	Group 3
1	96	104	102
2	98	106	104
3	113	123	120
4	79	87	87
5	99	110	109
6	130	144	143
7	82	90	89
8	92	101	100
9	106	116	113
10	96	103	103
11	104	113	111
12	133	144	142
13	103	109	107
14	114	120	118
15	108	114	112
16	102	108	106
17	110	116	114
18	110	116	114

TABLE 9

Number of Employees Ratings Plus Allowances
Using Single-Image Film

Film No.	Group 1	Group 2	Group 3
1	114	113	111
2	115	114	112
3	153	152	150
4	96	90	94
5	121	113	119
6	159	149	156
7	84	80	82
8	94	91	92
9	108	105	105
10	110	104	108
11	119	113	116
12	152	144	149
13	116	113	112
14	128	123	124
15	122	119	118
16	121	122	118
17	126	127	121
18	126	127	121

Table 1

Summary of the results of the analysis of variance

for the different groups

Group	Mean	Standard Error	Significance
1	1.12	0.11	0.1
2	1.11	0.11	0.1
3	1.02	0.11	0.1
4	0.95	0.11	0.1
5	0.87	0.11	0.1
6	0.81	0.11	0.1
7	0.75	0.11	0.1
8	0.70	0.11	0.1
9	0.65	0.11	0.1
10	0.60	0.11	0.1
11	0.55	0.11	0.1
12	0.50	0.11	0.1
13	0.45	0.11	0.1
14	0.40	0.11	0.1
15	0.35	0.11	0.1
16	0.30	0.11	0.1
17	0.25	0.11	0.1
18	0.20	0.11	0.1
19	0.15	0.11	0.1
20	0.10	0.11	0.1

TABLE 10

Number of Employees Ratings Plus Allowances
Using Multi-Aid Film

Film No.	Group 1	Group 2	Group 3
1	107	128	113
2	108	130	114
5	125	139	132
4	104	104	100
5	131	130	125
6	173	172	165
7	86	93	89
8	97	100	101
9	112	120	116
10	123	124	123
11	133	134	133
12	170	171	170
13	122	122	118
14	135	135	130
15	128	129	123
16	128	131	127
17	135	136	132
18	135	136	132

Table 20

Number of employees in the United States, by industry, 1947-1954

(Thousands of persons)

Industry	1947	1948	1949	1950	1951	1952	1953	1954
1. Agriculture, forestry, and fishing	1,121	1,121	1,121	1,121	1,121	1,121	1,121	1,121
2. Mining and construction	1,121	1,121	1,121	1,121	1,121	1,121	1,121	1,121
3. Manufacturing	1,121	1,121	1,121	1,121	1,121	1,121	1,121	1,121
4. Commerce and services	1,121	1,121	1,121	1,121	1,121	1,121	1,121	1,121
5. Government	1,121	1,121	1,121	1,121	1,121	1,121	1,121	1,121
6. Transportation and communication	1,121	1,121	1,121	1,121	1,121	1,121	1,121	1,121
7. Health, education, and social services	1,121	1,121	1,121	1,121	1,121	1,121	1,121	1,121
8. Other	1,121	1,121	1,121	1,121	1,121	1,121	1,121	1,121
Total	1,121	1,121	1,121	1,121	1,121	1,121	1,121	1,121

TABLE 11

Experience Ratings Using Judgment

Film No.	Group 1	Group 2	Group 3	Group 4
1	102	105	104	101
2	104	107	106	105
3	120	125	122	119
4	86	89	87	84
5	108	112	109	106
6	142	146	145	139
7	85	91	90	88
8	95	102	101	99
9	110	117	116	114
10	101	105	104	102
11	109	115	112	110
12	140	145	144	140
13	104	109	107	107
14	117	121	118	117
15	111	115	112	113
16	106	107	107	106
17	114	115	116	114
18	114	115	116	114

Demographic and clinical characteristics

# group	C group	C group	T group	Age (yr)
10	10	10	10	4
10	10	10	10	5
10	10	10	10	6
10	10	10	10	7
10	10	10	10	8
10	10	10	10	9
10	10	10	10	10
10	10	10	10	11
10	10	10	10	12
10	10	10	10	13
10	10	10	10	14
10	10	10	10	15
10	10	10	10	16
10	10	10	10	17
10	10	10	10	18
10	10	10	10	19
10	10	10	10	20
10	10	10	10	21
10	10	10	10	22
10	10	10	10	23
10	10	10	10	24
10	10	10	10	25
10	10	10	10	26
10	10	10	10	27
10	10	10	10	28
10	10	10	10	29
10	10	10	10	30
10	10	10	10	31
10	10	10	10	32
10	10	10	10	33
10	10	10	10	34
10	10	10	10	35
10	10	10	10	36
10	10	10	10	37
10	10	10	10	38
10	10	10	10	39
10	10	10	10	40
10	10	10	10	41
10	10	10	10	42
10	10	10	10	43
10	10	10	10	44
10	10	10	10	45
10	10	10	10	46
10	10	10	10	47
10	10	10	10	48
10	10	10	10	49
10	10	10	10	50
10	10	10	10	51
10	10	10	10	52
10	10	10	10	53
10	10	10	10	54
10	10	10	10	55
10	10	10	10	56
10	10	10	10	57
10	10	10	10	58
10	10	10	10	59
10	10	10	10	60
10	10	10	10	61
10	10	10	10	62
10	10	10	10	63
10	10	10	10	64
10	10	10	10	65
10	10	10	10	66
10	10	10	10	67
10	10	10	10	68
10	10	10	10	69
10	10	10	10	70
10	10	10	10	71
10	10	10	10	72
10	10	10	10	73
10	10	10	10	74
10	10	10	10	75
10	10	10	10	76
10	10	10	10	77
10	10	10	10	78
10	10	10	10	79
10	10	10	10	80
10	10	10	10	81
10	10	10	10	82
10	10	10	10	83
10	10	10	10	84
10	10	10	10	85
10	10	10	10	86
10	10	10	10	87
10	10	10	10	88
10	10	10	10	89
10	10	10	10	90
10	10	10	10	91
10	10	10	10	92
10	10	10	10	93
10	10	10	10	94
10	10	10	10	95
10	10	10	10	96
10	10	10	10	97
10	10	10	10	98
10	10	10	10	99
10	10	10	10	100

TABLE 12
Experience Ratings Plus Allowances Using
Single-Image Film

File No.	Group 1	Group 2	Group 3	Group 4
1	109	112	112	113
2	111	114	123	114
3	126	131	151	152
4	89	95	97	97
5	115	119	122	132
6	149	156	162	160
7	74	87	112	83
8	83	99	97	95
9	96	113	112	108
10	101	109	111	108
11	109	118	120	116
12	139	150	152	149
13	109	122	114	117
14	120	125	128	129
15	114	117	121	125
16	106	120	117	125
17	109	125	121	127
18	109	125	121	127

Approximate average size (mm) of fish

Approximate average size (mm) of fish				
Year	1960	1961	1962	1963
1	100	100	100	100
2	100	100	100	100
3	100	100	100	100
4	100	100	100	100
5	100	100	100	100
6	100	100	100	100
7	100	100	100	100
8	100	100	100	100
9	100	100	100	100
10	100	100	100	100
11	100	100	100	100
12	100	100	100	100
13	100	100	100	100
14	100	100	100	100
15	100	100	100	100
16	100	100	100	100
17	100	100	100	100
18	100	100	100	100
19	100	100	100	100
20	100	100	100	100
21	100	100	100	100
22	100	100	100	100
23	100	100	100	100
24	100	100	100	100
25	100	100	100	100
26	100	100	100	100
27	100	100	100	100
28	100	100	100	100
29	100	100	100	100
30	100	100	100	100

TABLE 15
Experience Ratings Plus Allowances
Using Multi-Image Film

Film No.	Group 1	Group 2	Group 3
1	113	113	116
2	116	115	119
3	133	133	137
4	103	102	102
5	123	130	129
6	170	171	170
7	90	94	92
8	101	103	103
9	113	121	118
10	123	127	122
11	132	137	131
12	169	179	168
13	123	119	121
14	136	131	133
15	129	124	127
16	131	130	130
17	137	134	134
18	137	134	134

Approximate weights (in kilograms)

of the following species

Species	Weight (kg)	Species	Weight (kg)
1.11	1.11	1.11	1.11
1.12	1.12	1.12	1.12
1.13	1.13	1.13	1.13
1.14	1.14	1.14	1.14
1.15	1.15	1.15	1.15
1.16	1.16	1.16	1.16
1.17	1.17	1.17	1.17
1.18	1.18	1.18	1.18
1.19	1.19	1.19	1.19
1.20	1.20	1.20	1.20
1.21	1.21	1.21	1.21
1.22	1.22	1.22	1.22
1.23	1.23	1.23	1.23
1.24	1.24	1.24	1.24
1.25	1.25	1.25	1.25
1.26	1.26	1.26	1.26
1.27	1.27	1.27	1.27
1.28	1.28	1.28	1.28
1.29	1.29	1.29	1.29
1.30	1.30	1.30	1.30
1.31	1.31	1.31	1.31
1.32	1.32	1.32	1.32
1.33	1.33	1.33	1.33
1.34	1.34	1.34	1.34
1.35	1.35	1.35	1.35
1.36	1.36	1.36	1.36
1.37	1.37	1.37	1.37
1.38	1.38	1.38	1.38
1.39	1.39	1.39	1.39
1.40	1.40	1.40	1.40
1.41	1.41	1.41	1.41
1.42	1.42	1.42	1.42
1.43	1.43	1.43	1.43
1.44	1.44	1.44	1.44
1.45	1.45	1.45	1.45
1.46	1.46	1.46	1.46
1.47	1.47	1.47	1.47
1.48	1.48	1.48	1.48
1.49	1.49	1.49	1.49
1.50	1.50	1.50	1.50

TABLE 14

Concept of Standard Ratings Using Judgment

File No.	Group 1	Group 2
1	103	102
2	105	104
3	122	120
4	86	87
5	100	110
6	143	144
7	89	89
8	100	100
9	115	115
10	103	103
11	112	111
12	143	142
13	108	107
14	119	118
15	113	112
16	107	106
17	113	114
18	113	114

Table

Summary of the results of the experiments

Series	Group	Mean	Standard Error
1	101	10.0	0.5
2	102	10.5	0.5
3	103	11.0	0.5
4	104	11.5	0.5
5	105	12.0	0.5
6	106	12.5	0.5
7	107	13.0	0.5
8	108	13.5	0.5
9	109	14.0	0.5
10	110	14.5	0.5
11	111	15.0	0.5
12	112	15.5	0.5
13	113	16.0	0.5
14	114	16.5	0.5
15	115	17.0	0.5
16	116	17.5	0.5
17	117	18.0	0.5
18	118	18.5	0.5
19	119	19.0	0.5
20	120	19.5	0.5

TABLE 15
 Concept of Standard Ratings Plus
 Allowances Using Single-Image Film

Film No.	Group 1	Group 2
1	112	112
2	114	114
3	131	132
4	97	97
5	121	122
6	160	160
7	86	82
8	96	92
9	111	103
10	106	115
11	115	124
12	148	139
13	116	113
14	128	125
15	121	119
16	121	119
17	123	124
18	125	124

LIST OF PLANTS IN THE GARDEN

PLANTS IN THE GARDEN

PLANT	PLANT	PLANT
1. 100	1. 100	1. 100
2. 100	2. 100	2. 100
3. 100	3. 100	3. 100
4. 100	4. 100	4. 100
5. 100	5. 100	5. 100
6. 100	6. 100	6. 100
7. 100	7. 100	7. 100
8. 100	8. 100	8. 100
9. 100	9. 100	9. 100
10. 100	10. 100	10. 100
11. 100	11. 100	11. 100
12. 100	12. 100	12. 100
13. 100	13. 100	13. 100
14. 100	14. 100	14. 100
15. 100	15. 100	15. 100
16. 100	16. 100	16. 100
17. 100	17. 100	17. 100
18. 100	18. 100	18. 100
19. 100	19. 100	19. 100
20. 100	20. 100	20. 100

TABLE 16
 Concept of Standard Ratings Plus
 Allowances Using Multi-Image Film

Film No.	Group 1	Group 2
1	114	116
2	116	117
3	135	136
4	103	93
5	129	128
6	171	168
7	91	94
8	102	103
9	116	121
10	122	123
11	132	136
12	169	172
13	120	121
14	133	134
15	127	128
16	120	129
17	134	134
18	134	134

Table 1

Summary of the results of the analysis

of the data for the period 1970-1979

Year	Value	Value
1970	1.0	1.0
1971	1.1	1.1
1972	1.2	1.2
1973	1.3	1.3
1974	1.4	1.4
1975	1.5	1.5
1976	1.6	1.6
1977	1.7	1.7
1978	1.8	1.8
1979	1.9	1.9
1980	2.0	2.0
1981	2.1	2.1
1982	2.2	2.2
1983	2.3	2.3
1984	2.4	2.4
1985	2.5	2.5
1986	2.6	2.6
1987	2.7	2.7
1988	2.8	2.8
1989	2.9	2.9
1990	3.0	3.0

TABLE 17

Size of Town Ratings Plus Allowances

Using Single-Image Film

Film No.	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6
1	119	111	112	114	110	117
2	121	113	114	116	112	119
3	139	130	132	135	130	138
4	103	97	99	103	106	106
5	131	122	124	128	133	133
6	174	161	164	169	176	175
7	95	92	86	87	87	98
8	106	103	99	99	98	110
9	123	135	114	113	112	126
10	120	119	120	121	128	133
11	130	128	130	131	138	143
12	166	163	166	167	177	184
13	121	124	116	117	119	130
14	134	137	129	130	131	143
15	128	130	122	123	124	136
16	132	130	122	128	137	132
17	137	134	127	133	143	137
18	137	134	127	133	143	137

TABLE IV

List of new objects from 1950-1955

1950-1955 (continued)

Object	Object	Object	Object	Object	Object	Object
111	112	113	114	115	116	117
118	119	120	121	122	123	124
125	126	127	128	129	130	131
132	133	134	135	136	137	138
139	140	141	142	143	144	145
146	147	148	149	150	151	152
153	154	155	156	157	158	159
160	161	162	163	164	165	166
167	168	169	170	171	172	173
174	175	176	177	178	179	180
181	182	183	184	185	186	187
188	189	190	191	192	193	194
195	196	197	198	199	200	201
202	203	204	205	206	207	208
209	210	211	212	213	214	215
216	217	218	219	220	221	222
223	224	225	226	227	228	229
230	231	232	233	234	235	236
237	238	239	240	241	242	243
244	245	246	247	248	249	250

TABLE 18

Size of Town Ratings Plus Allowances

Using Multi-Image Film

Film No.	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6
1	103	105	103	104	112	98
2	105	107	104	105	113	100
3	121	124	121	122	131	115
4	85	91	85	87	95	84
5	107	114	107	109	119	105
6	141	150	140	144	157	158
7	88	91	91	88	91	89
8	98	102	102	99	102	100
9	113	117	117	114	117	115
10	103	107	100	104	109	105
11	111	115	108	112	117	111
12	142	147	138	144	150	142
13	107	116	109	108	113	102
14	119	128	119	119	125	112
15	113	122	113	113	119	107
16	106	112	107	106	114	101
17	114	121	115	114	122	109
18	114	121	115	114	122	109

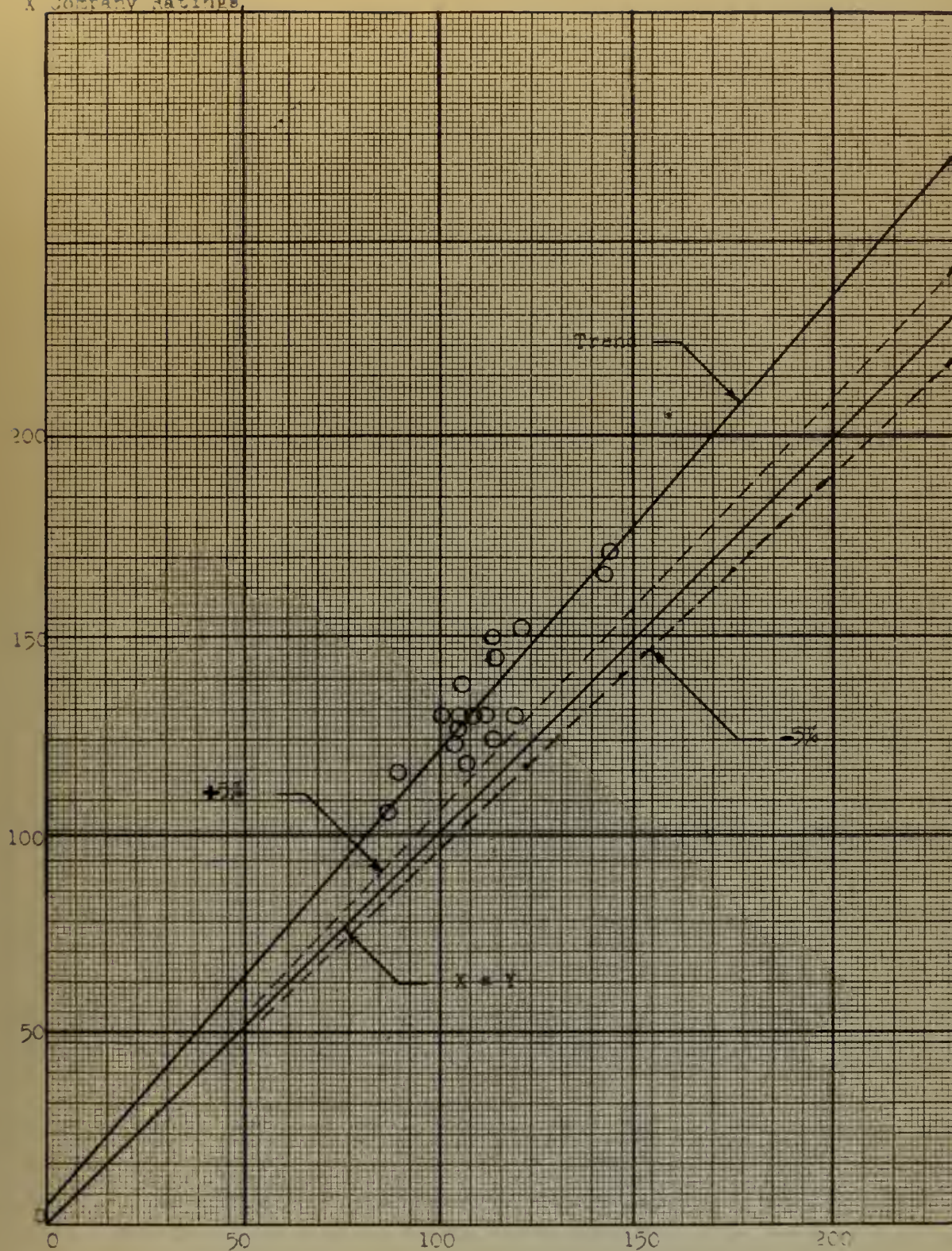
Summary of the results of the survey

of the survey of the

1. year	2. year	3. year	4. year	5. year	6. year	7. year
1875	1876	1877	1878	1879	1880	1881
1882	1883	1884	1885	1886	1887	1888
1889	1890	1891	1892	1893	1894	1895
1896	1897	1898	1899	1900	1901	1902
1903	1904	1905	1906	1907	1908	1909
1910	1911	1912	1913	1914	1915	1916
1917	1918	1919	1920	1921	1922	1923
1924	1925	1926	1927	1928	1929	1930
1931	1932	1933	1934	1935	1936	1937
1938	1939	1940	1941	1942	1943	1944
1945	1946	1947	1948	1949	1950	1951
1952	1953	1954	1955	1956	1957	1958
1959	1960	1961	1962	1963	1964	1965
1966	1967	1968	1969	1970	1971	1972
1973	1974	1975	1976	1977	1978	1979
1980	1981	1982	1983	1984	1985	1986
1987	1988	1989	1990	1991	1992	1993
1994	1995	1996	1997	1998	1999	2000

Figure 1

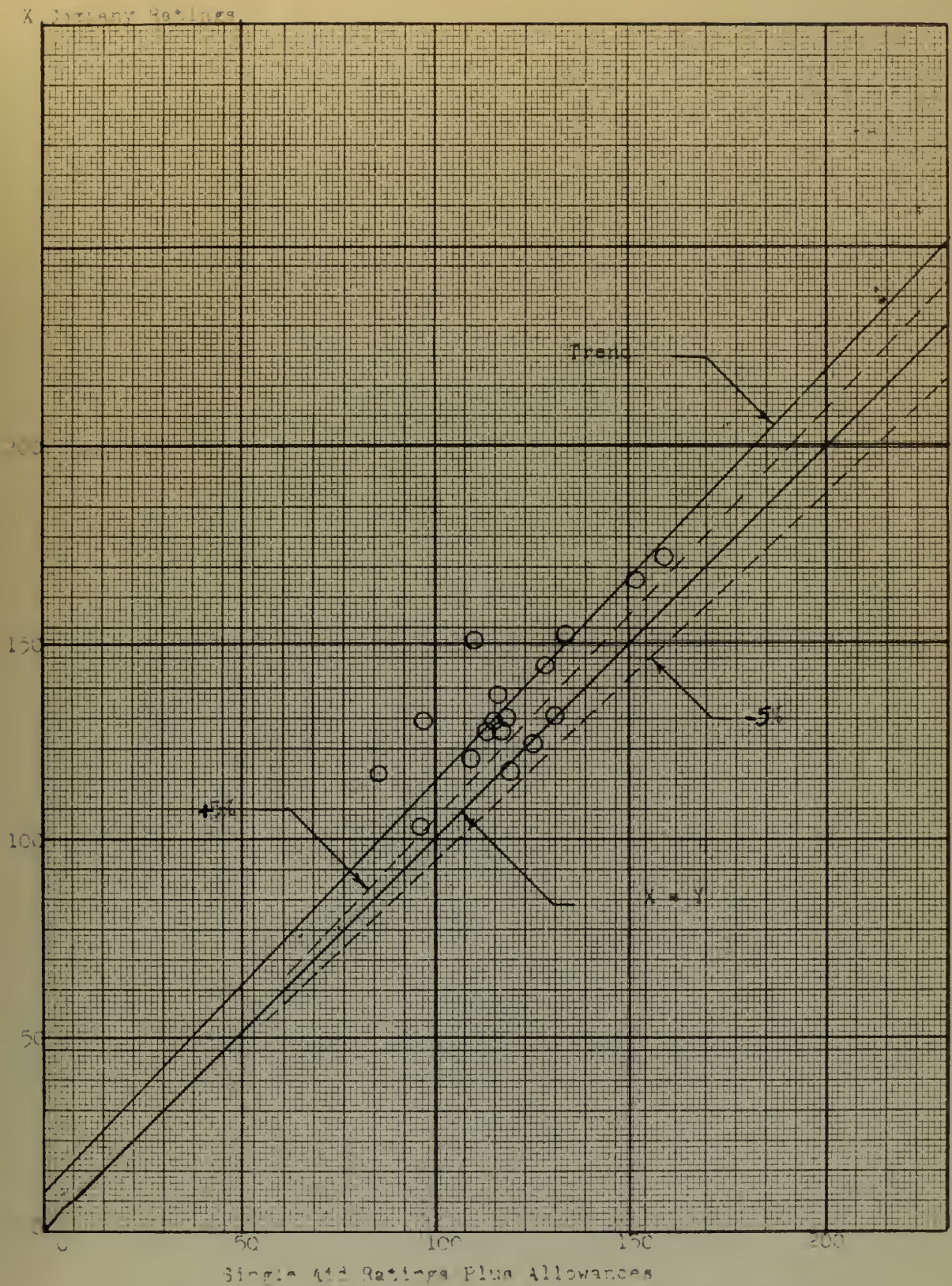
X Company Ratings



Judgment Ratings

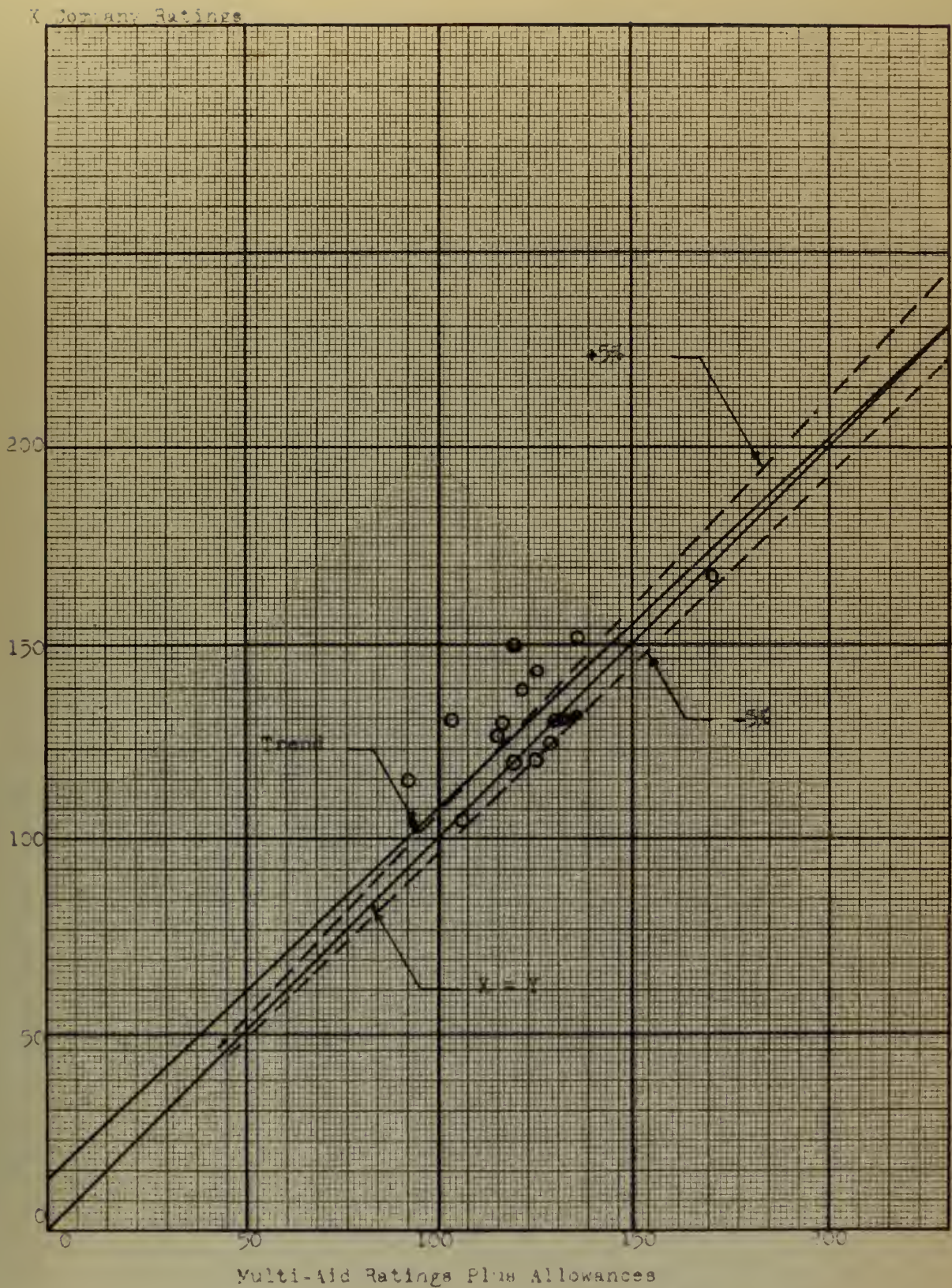
Judgment Ratings Versus X Company Ratings

Figure 2



Single Aid Ratings Plus Allowances Versus X January Ratings

Figure 3



Multi-Aid Ratings Plus Allowances Versus X Company Ratings

FIGURE 4
TIME STUDY WORK SESSION QUESTIONNAIRE

BSB-TSQ #1-FD

BE SURE TO COPY THE FIRST THREE DIGITS OF YOUR CARD DECK NUMBER IN THE SPACE PROVIDED. Please answer all questions as accurately as possible. Circle number to left of appropriate answer. All of the information on this questionnaire is considered CONFIDENTIAL. Neither your name nor the company name will be revealed in any way.

1.	2.	3.

A. Name _____

B. Company _____

4. Mailing Address _____

5. What characterizes the direct labor in your plant:

1. Bench work
2. Machine work
3. Gross body movements (moving around)
4. Equal amounts of all three named above.

6. Number of employees in your plant.

1. 50 or less
2. 51 to 100
3. 101 to 200
4. 201 to 300
5. 301 to 500
6. 501 to 750
7. 751 to 1000
8. 1001 to 1500
9. Over 1500

7. Length of time you have been making time studies.

1. Less than six months and actively engaged
2. Less than six months, but not now actively engaged
3. More than six months, but less than a year and actively engaged
4. More than six months, but less than a year and not now actively engaged
5. More than one year, but less than two years and actively engaged
6. More than one year, but less than two years and now now actively engaged
7. Two to four years
8. Five to ten years
9. Over ten years

8. Where did you receive your initial time study training? Give name and location.

1. College _____
2. Extension _____
3. Company _____
4. Other _____

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Use
(9) (10)

11. Do you rate compared to

1. your concept of standard performance
2. some film or other embodiment of standard performance

12. Do you rate

1. pace
2. rate of activity
3. speed of movement
4. skill and effort
5. effort
6. skill, effort, conditions, and consistency (Westinghouse)
7. effective speed
8. attitude plus other factors
9. Other _____

13. Which method do you use for your ratings?

1. a point basis
2. a percentage basis

14. Do you use wage incentives?

1. Yes
2. No

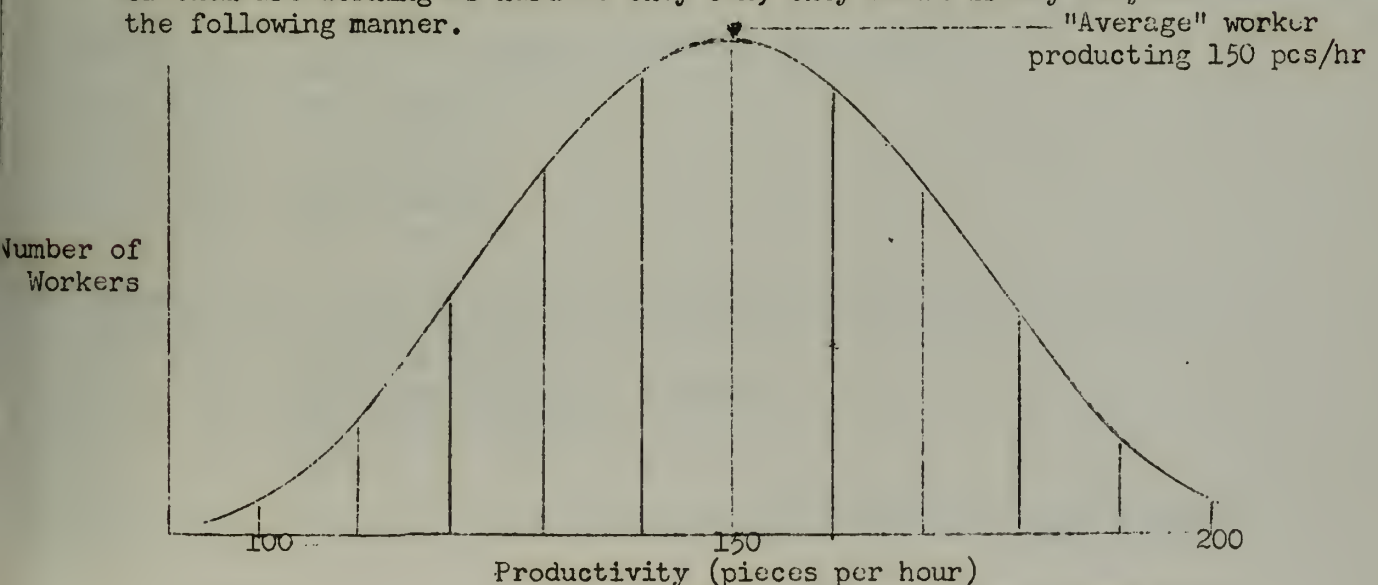
15. Do you apply an incentive allowance to final computed time study results?

1. Yes, how much _____
2. No.

17. What is the percent increment or ratio by which the typical employee can exceed the standard? _____

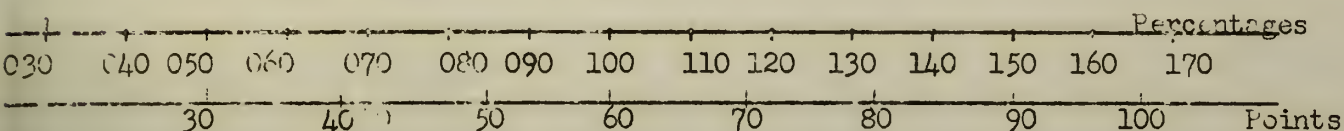
18. Please define the Standard performance which you use as a basis for your ratings in terms of "who", "doing what", and "Working how".

19. Assuming you have a large number of workers on one job, and that all of them are working as hard as they can, they would likely vary in the following manner.



(Question 19 continued on next page)

19. (Con't) Please indicate on the following scale the rating value you would assign if you observed the "average" worker working as hard as he could and producing 150 pieces per hour. Mark the appropriate scale at the appropriate place.



22. When studying a job, do you require a performance within a certain range?
(Such as requiring a performance between 80% and 120% before the study is made).
If so, please state limits.

Use one set of appropriate blanks.

_____ to _____ percentages
_____ to _____ points

23. Do you have a union in your plant?

1. yes
2. no

24. Do you have union participation in your time studies?

1. yes
2. no

25. What is your position in the organization of the plant?

1. Head of Industrial Engineering Dept.
2. Member of staff of Indust. Eng. Dept.
3. Head of Time Study Dept.
4. Member of staff of Time study dept.
5. Head of Production Department
6. Member of Staff of Production Dept.
7. Head of Control Dept.
8. Member of staff of Control Dept.
9. Other _____

26. Do you have an engineering degree?

1. Yes
2. No

27. About how long has your plant been making time studies?

1. Less than a year
2. 1 to 3 years
3. 4 to 6 years
4. 7 to 10 years
5. Over 10 years
6. I don't know.

28. Which of the following methods of recording time studies do you make the most use of in your plant?

1. Continuous timing
2. Repetitive (snap-back) timing
3. Accumulative timing
4. Camera

29. About what percentage of the employees in your plant are union members?

_____ %.

30. If your union contract contains sections pertaining to time study work, which of the following may be found in your contract?
1. Definition of Standard
 2. Incentive Gap (earnings over standard)
 3. Time study grievance procedure
 4. Other _____

 5. I don't know.
31. If the head of a department, to whom do you report or to whom does your head report?
1. Vice president in charge of Manufacturing
 2. General Manager
 3. Comptroller
 4. Superintendent
 5. Plant Manager
 6. Other _____
32. If you are, or were to be, head of a department, to whom do you think you should report?
1. Vice President in charge of Manufacturing
 2. General Manager
 3. Comptroller
 4. Superintendent
 5. Plant Manager
 6. Other _____
33. Do you consider the position you hold carries with it enough authority to put into operation the plans and ideas you have?
1. Yes
 2. No
34. If you are not satisfied with the position you now hold, what position do you think would best suit your needs (with reference to better time studies)?

35. Were you hired directly into the time study department?
1. Yes
 2. No
36. If transferred to the time study department, what department were you in before the transfer occurred? _____
37. Are you satisfied with the salary you receive?
1. Yes
 2. No
38. What is the extent of your education?
1. Grammar School
 2. High School
 3. Trade School
 4. Business School
 5. College (list all degrees) _____

39. If a graduate engineer, do you hold an "Engineer-In Training" certificate?
1. Yes
2. No
40. If a graduate engineer, do you hold a Professional Engineer's License?
1. Yes
2. No
41. What is the minimum amount of education you believe necessary for time study work?
1. Grammar School
2. High School
3. College
42. Do you consider a college education _____ for time study work?
1. essential
2. desirable
3. unnecessary
43. If you are of the opinion that a college education is essential or desirable, how many years would you recommend? _____ years.
44. What type of college education do you consider best suited to time study work?
1. Engineering
2. Business
3. Science
4. Other _____
45. Do you consider shop experience _____ for time study work?
1. Essential
2. Desirable
3. Unnecessary
46. If you consider shop experience to be essential or desirable, how much experience would you recommend? _____ years
47. Is there an Industrial Engineering Department in your plant?
1. Yes
2. No
48. Is there a separate Time Study Department in your plant?
1. Yes
2. No
49. Total number of men on staff actively engaged in time study work. _____ men
50. Number of engineers on staff actively engaged in time study work.
_____ engineers
51. Number of union men on staff actively engaged in time study work. _____ men
52. Considering the number of employees in your plant, how many men do you believe should be on the time study staff? _____ men

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53. Do you believe that you have the cooperation of top management in doing your work?
1. Yes
 2. No
54. Do you believe your time study department to be sufficiently staffed with competent and well qualified personnel to do the job expected of it?
1. Yes
 2. No
55. Do the employees in your plant have a good understanding of time study principles?
1. Yes
 2. No
56. Is the educational program in your plant to give employees a better understanding of time study
1. adequate?
 2. inadequate?
 3. no program in effect.
57. Are the educational programs in your plant dealing with time study for the employees given on
1. company time?
 2. employees' time?
 3. a combination of both?
 4. none given
58. In general, are the employees in favor of time study?
1. Yes
 2. No
59. Do the employees cooperate with the time study staff?
1. Yes
 2. No
60. Do you believe that the foremen and supervisors in your plant are adequately educated in a proper understanding of modern time study practices?
1. Yes
 2. No
61. The educational program for foremen and supervisors on time study practices in your company is
1. adequate
 2. inadequate
 3. no program in effect.
62. Are the educational programs dealing with time study for foremen and supervisors given on
1. company time?
 2. employees' time?
 3. a combination of both?
63. Do you believe that a company should have a training program for its time study personnel?
1. Yes
 2. No

64. Does your company have a training program for its time study personnel that is
1. adequate
 2. inadequate
 3. no program in effect.
65. Are the training programs for time study men given on
1. company time?
 2. employees' time?
 3. a combination of both?
 4. none given
66. Is the training program for the union time study men the same as that for the company's men?
1. Yes
 2. No
 3. none for union men
67. If the answer to question (66) is no, is the training program for the union men
1. adequate?
 2. inadequate?
68. Is the training program for the union time study men given by
1. the union only?
 2. the company only?
 3. both the union and the company?
 4. an outside agency?
 5. none given
69. Does your company have any specific injunction against the use of motion pictures for methods study?
1. Yes
 2. No
70. Does your company have any specific injunction against the use of motion pictures for time study?
1. Yes
 2. No

FIGURE 5
CALIBRATION CHART

Bench mark value for each image of the Multi-Image rating loop

Images and their corresponding bench mark value are arranged in the Multi-Image loop as follows:

IMAGE NO.	BENCH MARK VALUE.	
1	2	3
155.8	143.8	137.6
4	5	6
132.4	122.8	118.5
7	8	9
105.3	98.7	95.3
10	11	12
93.0	81.6	79.2

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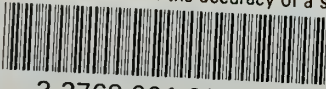
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